DOCUMENT RESUME

ED 427 502 EF 005 199

TITLE	Impact of Technology on School Facility Design.
INSTITUTION	North Carolina State Dept. of Public Instruction, Raleigh.
PUB DATE	1995-06-00
NOTE	29p.
PUB TYPE	Reports - Descriptive (141)
EDRS PRICE	MF01/PC02 Plus Postage.
DESCRIPTORS	Air Conditioning; Classroom Design; *Educational Facilities Design; *Educational Facilities Improvement; *Educational Technology; Elementary Secondary Education; *Public Schools
IDENTIFIERS	*Technological Infrastructure; *Technology Integration

ABSTRACT

Computers and other technological innovations are becoming a greater part of today's educational system requiring educational facility designers to plan for their use when designing or renovating new buildings. This booklet considers the building needs for accommodating new technology, particularly focusing on the impact of personal computers and their interconnectivity. It discusses space requirements for workstations and workstation layouts; the cooling and electrical requirements for personal computers; and the design considerations when building computer and keyboarding labs, media centers, head-end and file server rooms, special use rooms and vocational labs, and labs for distance learning and the information highway. Other uses of technology in schools are highlighted such as systems for food service, energy management, facility management, and network connections. The booklet's final section examines design considerations for network wiring and file server closets. (Contains 9 references.) (GR)

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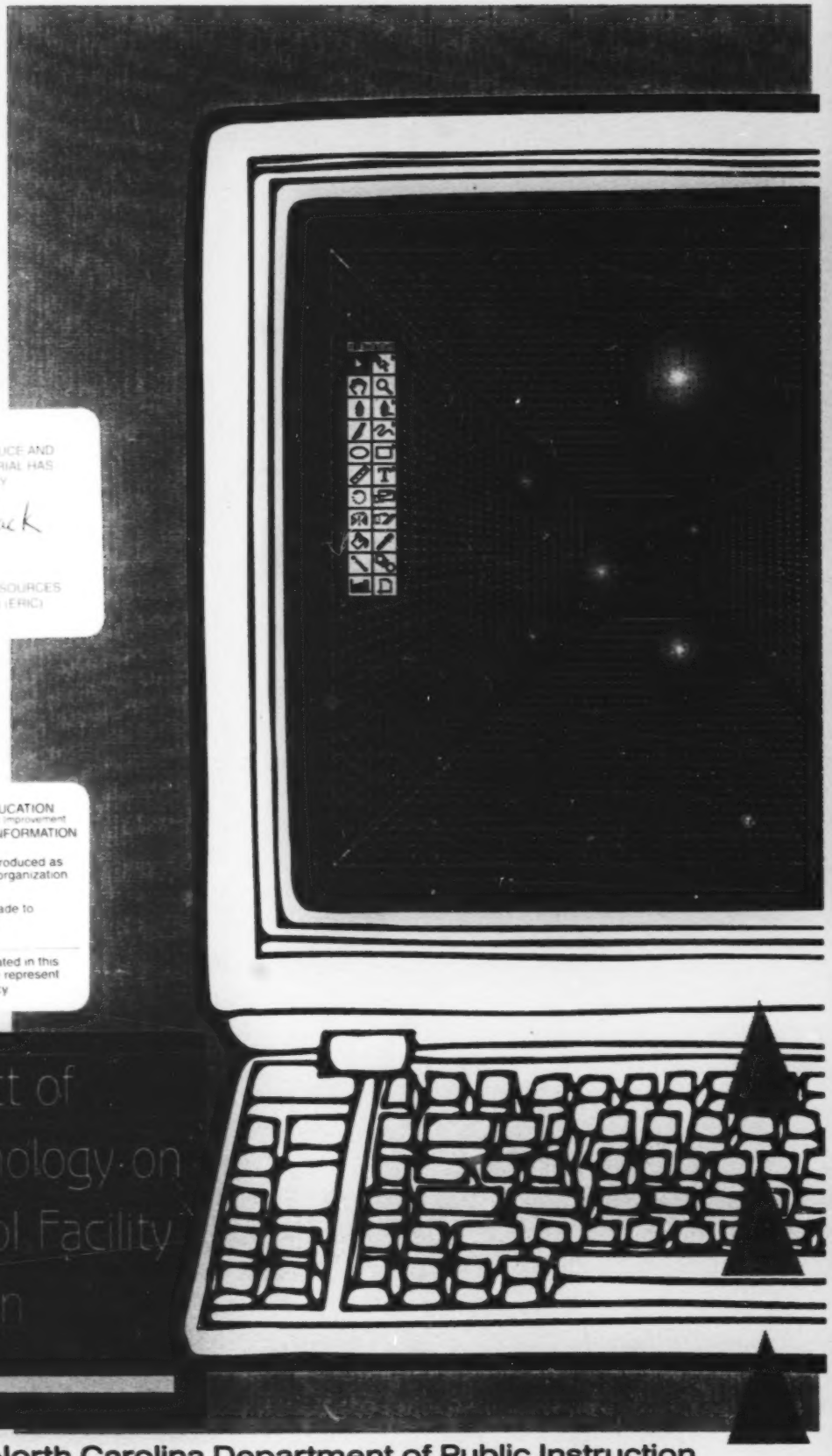

Impact of Technology on School Facility Design

June 1995

North Carolina Department of Public Instruction

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Foreword

School administrators, teachers, parents and students are well aware of the movement to implement technology in our schools. Computer labs, individual classroom computers, networks, integrated communications, video systems and other types of technology are being installed in our schools statewide. The cost of this technology is significant, not just for the equipment itself, but also for training of staff in its use and the maintenance and upgrade of hardware and software as the technology rapidly advances.

This technology, of course, impacts the building's physical facilities. Classrooms need to be larger to accommodate new equipment, additional rooms and closets are required to support the technology and the new equipment places increased demands upon electrical and air-conditioning systems.

This publication is offered as an aid in planning new and renovated facilities to accommodate this new technology.

Jay M. Robinson
Chairman,
State Board of Education

Bob Etheridge
State Superintendent,
Deparment of Public Instruction

Acknowledgements

School Planning, Department of Public Instruction, gratefully acknowledges the cooperation and assistance from individuals and groups in the preparation, review and editing of this publication. Without such cooperation, the development and printing of *The Impact of Technology on School Facility Design* would not have been possible.

We wish to express a special thanks to:

- Dr. Charles Weaver, Assistant State Superintendent, Auxiliary Services for his vision in identifying the need for this publication.
- Dr. Karen Gulledge, Chief Consultant, School Planning, for her leadership, input and review of the material presented.
- Steven Taynton, Consulting Architect, School Planning, for his research, development, writing and illustration of the publication.
- Gerald Knott, James Lora and Marjorie Acker, Consulting Architects, School Planning, for their review and input on the majority of the material presented herein.
- Ronald Harrell and Allen Winslow, Consulting Engineers, School Planning, for their review of electrical and mechanical aspects of this material.
- Margaret Bingham, Frances Bradburn and Linda De Grand, Chief Consultants within the Media and Technology Support Team for their input, review and comments on material related to their specialties.
- Eleanor Dixon, Administrative Assistant, School Planning, for editing and proofing of the final document.
- Communication Services, North Carolina Department of Public Instruction, for their assistance in the final production of the publication.
- Wake County, Durham County, Johnston County and Asheville City Schools for use of photographs of their technology installations to help illustrate this publication.

June 1995
School Planning
Division of School Facility Services
North Carolina Department of Public Instruction

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Introduction

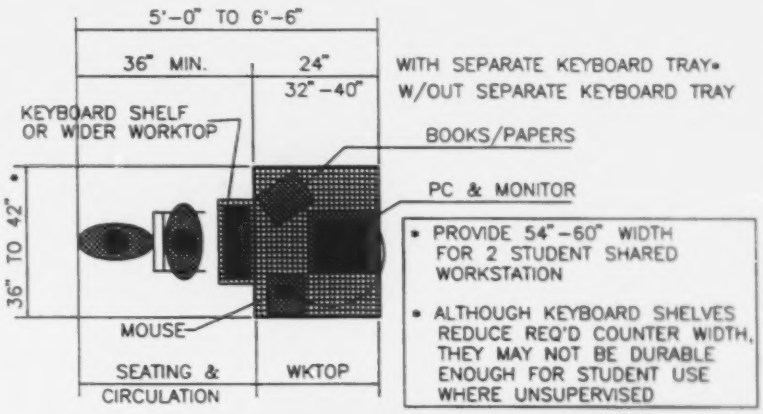
In the past two decades, the use of personal computers has pervaded our society. Their value as a tool for information management, science, mathematics, graphics and business is now widely recognized. With this technology has come a new and different set of spatial and environmental constraints that must be recognized and incorporated into our buildings to allow the effective use of this equipment. Spaces that once were designed for pen and paper, chalkboard and lecture are not the same as those that are needed for microcomputers or integrated voice, data and video communications.

This publication should be used in conjunction with the *North Carolina Instructional Technology Plan*, prepared by the North Carolina School Technology Commission, December 1994, and other materials listed in "References for Further Reading" at the end of this publication. The emphasis of the *North Carolina Instructional Technology Plan* is upon the **use of technology** in schools and the specific equipment to support those uses. The material presented in this pamphlet has a different emphasis—that of **building needs** to accommodate this technology equipment.

Many types of equipment and innovative ways of teaching or communicating can be included under the broad label of "technology." Aspects of technology in schools include such items as classroom to administration intercom systems, master TV systems, telephone and voice mail, personal computers, integrated communication systems, energy control systems, security systems, etc. Many choices are available to school systems for these types of technology; however, this publication deals primarily with the impact of personal computers and their interconnectivity. We plan to produce future publications that will examine other aspects of technology, as well as modifications resulting from future advances in technology.

Space Requirements for Personal Computers

The addition of one or two computers within a traditional classroom often has little, if any, impact upon the traditional classroom size. They can usually be accommodated on existing countertops, sometimes by removing a cabinet below for kneespace, or by simply placing a table at the wall for the computer(s).

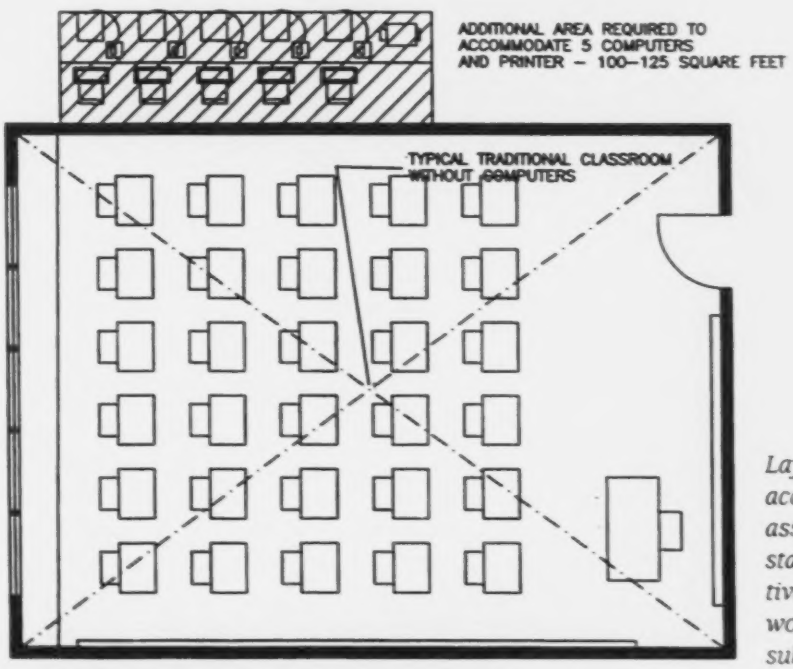


Space requirements per workstation: 15 SF to 21 SF plus printer space

More than two or three computers in a classroom, however, can have a significant impact upon spatial needs. Many elementary and middle school regular classrooms are being equipped with five student computers plus a workstation for the teacher. Even more are often planned for math, science or vocational classrooms. Each of these workstations require between 15 and 20 square feet. This allows space for the computer and monitor, keyboard, mouse and space for books or papers to use in conjunction with work on the computer, as well as space for a seated user and minimal circulation. Single printers and fileservers would need about the same amount of space. We can assume that the teacher's computer would be located at his or her desk and require no additional space; however, five student computers and a printer occupy about 100–125 additional square feet. With careful design, limited space savings can be realized by sharing some existing circulation area with that required for computer circulation. When planning new regular classrooms, the room size should be increased by 10%–15% to accommodate these workstations. Spaces such as computer and business labs, and other similar classes with large numbers of computers, require substantially more space to accommodate increased circulation, teaching areas and other functions.

An often used "rule of thumb" for computer printers to workstations is one laser or comparable speed printer for every five to eight workstations, depending upon the type of software being used. Intensive word processing, graphics or slower types of printers may require the installation of more than one printer. The printer(s) should be located in close proximity; therefore, if one printer for every classroom is provided, some moderate growth in the number of workstations can be accommodated without the need for additional printers.

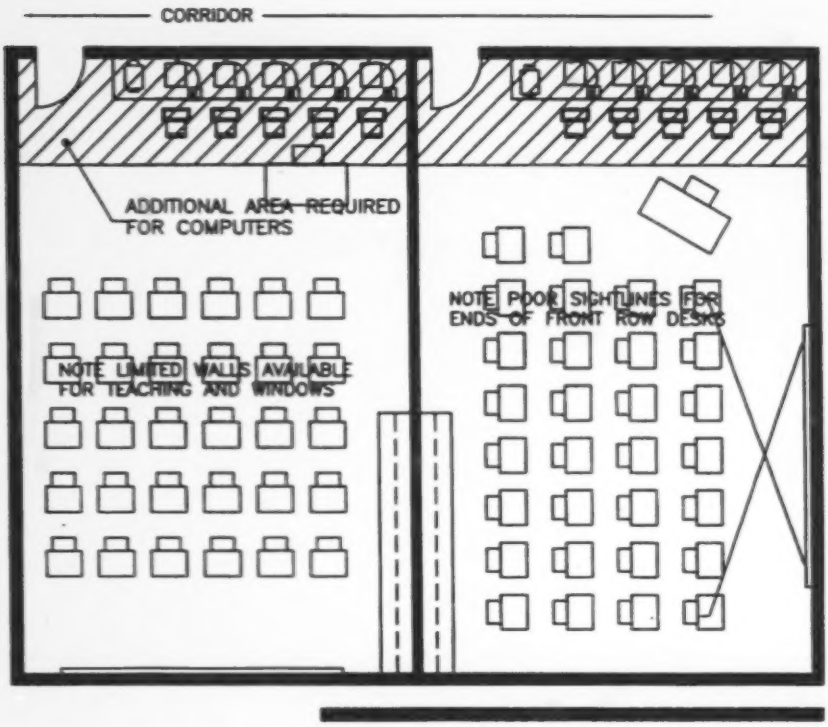
Location of the workstations within the classroom should be carefully considered. Ideally, visibility between the teacher and student should be maintained as well as the ability of the teacher to view the monitor screen from the normal teaching area. In addition, monitors should be located to prevent direct rays of light from the sun or light fixtures from striking their surfaces and producing glare on the screens. Indirect or parabolic reflector lighting fixtures should be considered to reduce glare in these areas and the use of matte (less reflective) worksurfaces also helps. The workstations should be located away from wet or dusty areas to reduce damage. Chalkboards should not be used due to the damaging dust produced by chalk; markerboards and similar newer types of surfaces are now available at reasonable cost.


ADDITIONAL AREA REQUIRED TO ACCOMMODATE 5 COMPUTERS AND PRINTER – 100–125 SQUARE FEET
TYPICAL TRADITIONAL CLASSROOM WITHOUT COMPUTERS

Layouts shown on the accompanying sketches assume single user workstations. Team or cooperative use of computer workstations require substantially more space.

Typical space required for personal computers in a regular classroom

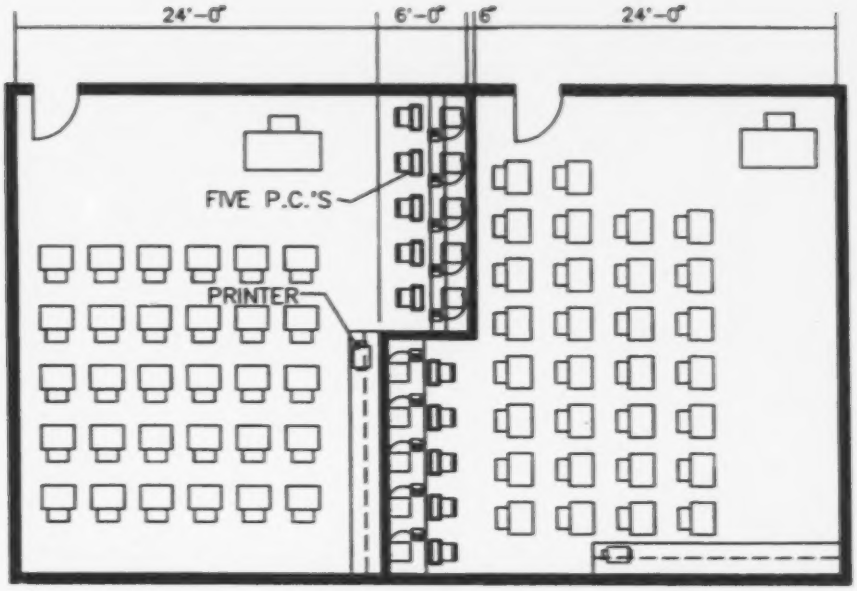
Workstations located along a wall, or extending out from a wall like a peninsula, allow traditional classroom use to continue without the difficulty and expense of underfloor wiring for power and network communications.


CORRIDOR
ADDITIONAL AREA REQUIRED FOR COMPUTERS
NOTE LIMITED WALLS AVAILABLE FOR TEACHING AND WINDOWS
NOTE POOR SIGHTLINES FOR ENDS OF FRONT ROW DESKS

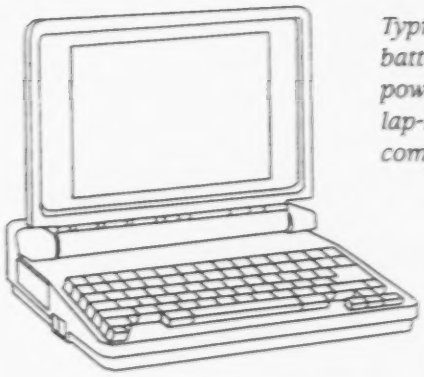
Example with computers along short wall adjacent to corridor

Schemes where the corridor wall is the classroom short wall and computers are placed along this side may result in less overall area increase and less cost for power and network wiring. A scheme of this type, however, may limit teaching walls and furniture arrangement to orientation to a long wall. This could result in poor sight lines for students unless classrooms are wider than 24 feet. Traditional rows of student desks are shown for illustrative purposes only and are not intended to discourage more flexible or innovative teaching arrangements.

The possibility of separate, shared computer labs between adjacent classrooms is sometimes discussed as a way to reduce costly computer resources. This approach may be shortsighted as more and more computers are introduced into the classroom. Further considerations include the loss of teacher control over students in a separate space and the loss of space flexibility as technology and educational philosophy changes in the coming years. Although simple rectangular rooms are probably best for overall future flexibility, a pair of alcoves or niches between classrooms may be a reasonable compromise, especially if the separating walls are constructed for possible reconfiguration as needs change. See the accompanying sketch.



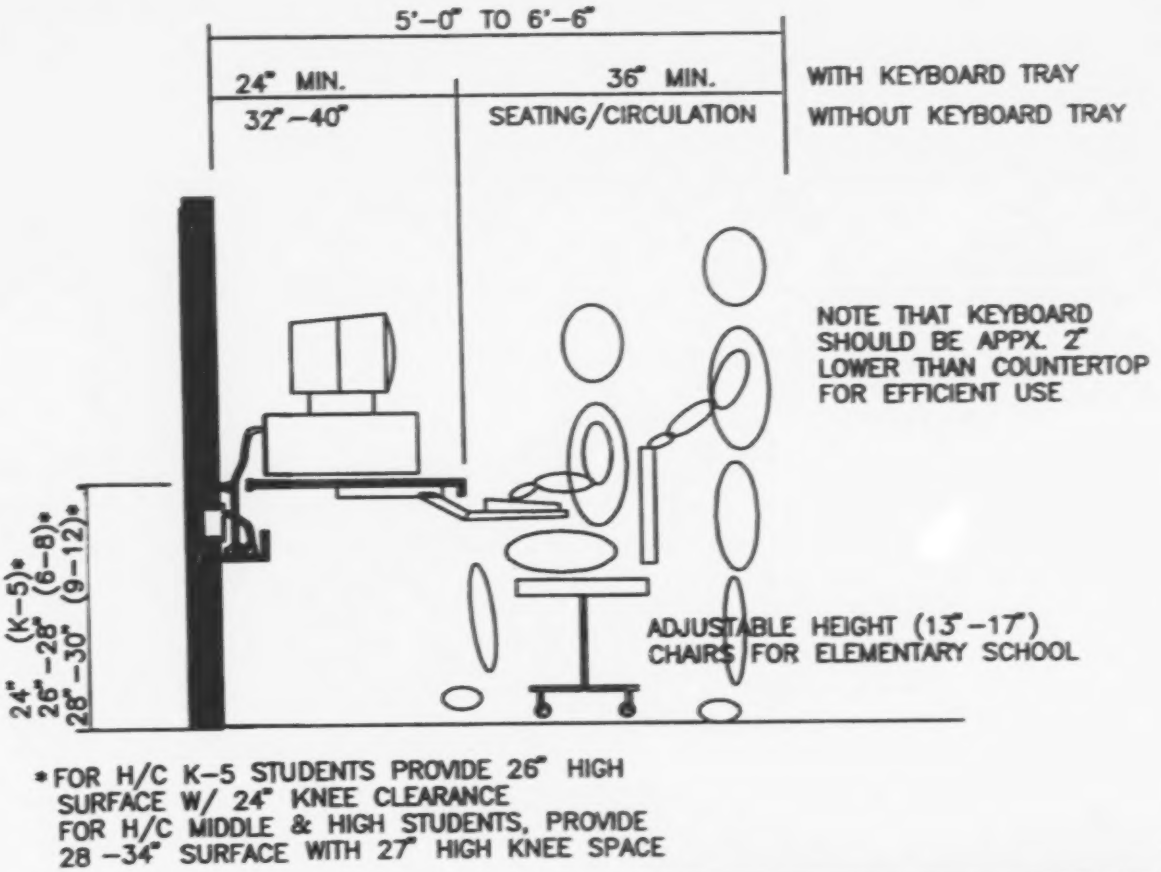
Non-structural classroom dividing wall to create computer niches (different wall arrangement may be desirable in future)



Typical battery powered lap-top computer

Issuing "laptop" computers to all students is often discussed as a potential future goal. As laptop computers become more durable, prevalent and lower in cost, their use may emerge as a trend. Their benefits are access by all students and the ability to take workstations home for assignments or independent work. These units have their own requirements which are likely to be very different from those of desktop workstations. Individual student desks will need to be larger, in order to accommodate this piece of equipment, along with the traditional books and papers. In addition, network connections will be necessary at each student's desk. It is also likely that "docking stations" with connection to full size monitors for specialized work will be necessary. The current trend of installing full size workstations could possibly allow their conversion to docking stations in the future.

Design of furniture and casework to manage and conceal the tangle of computer wiring has become increasingly important. Not only are the numerous cables unsightly, tampering or inadvertent pulling, tugging or tripping on wires can damage equipment or connectors and can be hazardous to users. Modern furniture and casework can be specified or designed to provide built-in, concealed wiring paths and raceways. Grommets in countertops as well as built-in outlets for both power and communications can easily be installed in most furniture and casework which will reduce the amount of exposed wiring to acceptable minimums. Should "wireless" networks become an economic reality, network connections at individual student desks would not even be required.

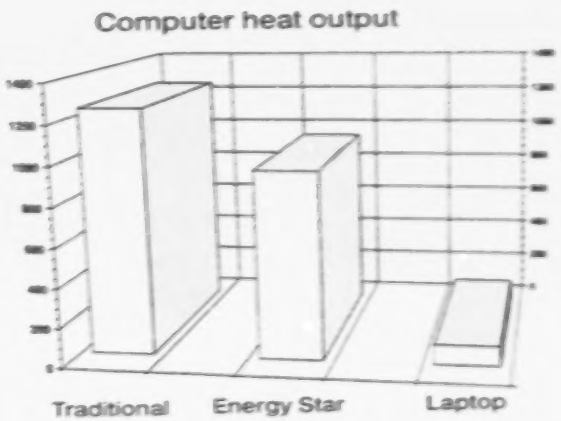

5'-0" TO 6'-6"
24" MIN.
32"-40"
36" MIN.
SEATING/CIRCULATION
WITH KEYBOARD TRAY
WITHOUT KEYBOARD TRAY
NOTE THAT KEYBOARD SHOULD BE APPX. 2" LOWER THAN COUNTERTOP FOR EFFICIENT USE
24" (K-5)*
26"-28" (6-8)*
28"-30" (9-12)*
ADJUSTABLE HEIGHT (13"-17") CHAIRS FOR ELEMENTARY SCHOOL
* FOR H/C K-5 STUDENTS PROVIDE 26" HIGH SURFACE W/ 24" KNEE CLEARANCE
FOR H/C MIDDLE & HIGH STUDENTS, PROVIDE 28-34" SURFACE WITH 27" HIGH KNEE SPACE

Typical computer countertop

Cooling Requirements for Personal Computers

Like all electrical appliances, personal computers and printers produce heat as a by-product of their operation. With one or two computers located in a classroom, the amount of heat produced is probably negligible compared to the normal heat generated by people, lights, infiltration through doors and windows and heat gain through walls and roofs. As we increase the number of computers, however, their added load becomes significant and must be considered. This is true both for new buildings when designing air conditioning systems and for existing structures where the existing system may become over-taxed.

Computers require a relatively narrow band of temperature and humidity for their operation. If this band is exceeded, they often will stop working unexpectedly, their lifespan may be significantly reduced and/or they may suffer permanent damage. A single, typical personal computer will produce 1,300 BTUH or more of heat depending upon the amount of options installed and the type of monitor (including an allowance for a shared laser printer for each six workstations). This computer load translates to 3/4 of a ton of air conditioning for six computers and a printer. Small air conditioning equipment is manufactured in logical 1 ton steps (larger equipment-such as for an entire wing may be in 5 or 10 ton steps). For a typical classroom with a two- to three-ton air conditioning load without computers, this can mean an additional ton of air conditioning equipment for six computers.



The newer "green" or "energy star" computers and monitors advertise substantially lower energy consumption and heat output. This is true, but only when the computers are not being used. These computers go into a "sleep" mode with very low energy consumption when the keyboard or mouse has not been used for a specified period of time. When in operation (which is their purpose in the classroom), their heat output and energy consumption is about the same as for traditional computers.

Laptop computers use substantially less energy and produce much less heat than standard workstations. A typical battery powered laptop produces less than 60 BTUH of heat or only about 5% of the amount for a comparable desktop unit and monitor. If laptops become general usage for students and teachers, very little additional electrical or air conditioning capacity for schools will be required. However, until the problems of ease of loss or damage to these small and expensive units are overcome, laptop computers may not see widespread use in the classroom.

Electrical Requirements for Personal Computers

Personal computers can require substantial amounts of electrical capacity. When a typical desktop workstation with a full sized monitor is equipped with optional accessories, such as CD-ROM, sound cards, extra hard drives, etc., it is capable of drawing up 500 watts (or more) of electrical power. With consumption at this level, no more than two to four computers/monitors (depending upon actual consumption) should be connected to a single 20 amp circuit. A laser printer should have its own, dedicated circuit to prevent voltage drop to other computers when it starts to print. For a typical classroom with six computers and a printer, three to four circuits for computer/ printer use comprised of two or more duplex outlets per workstation should be installed. This is in addition to a circuit for the TV and other circuits for convenience outlets around the room.

Computers also generate high levels of electrical harmonic distortion. This can cause problems when numerous computers are installed. Special considerations such as oversized neutral wires and specially designed transformers should be specified by an electrical engineer when implementing significant numbers of computers.

Once again, laptop computers require substantially less electrical capacity. If operated on battery power alone, the only electrical capacity needed is for battery recharge, which is nominal. Realistically, several full size monitors as an alternative to LCD screens should be provided for graphics work. These monitors could probably use the standard convenience outlets already installed in a traditional classroom.

File servers should have uninterruptible power supplies (UPS) to let them power down safely in the event of a power loss from the local utility company. It may be more cost effective to place all file servers on the same circuits backed by one common UPS rather than separate UPS devices for each file server.

All computers should be on isolated circuits that are equipped with surge suppression. This can be accomplished either with stand alone surge suppressors or by protection of the circuit at the panelboard.

Ideal placement of power and network outlets is in a permanent wall so that cords and cables can be effectively managed. Workstations located in the interior of the room on tables or casework are much more difficult to supply with power and network communications. When interior workstations are installed, they must be supplied either from overhead by the use of power poles, from floor mounted receptacles or low (table height) knee walls. Knee walls are the preferred choice but they limit flexibility in furniture arrangement and future alteration of the space. Both power poles and floor receptacles have even more significant disadvantages.

Power poles which provide feeds from above the ceiling to desk or floor height tend to become easily damaged because they are light in weight and non-structural. They are often knocked loose from their anchorages at the floor, ceiling or both, resulting in electrical hazards. In addi-

tion, they are usually considered unsightly and disrupt the view between students, teacher and teaching walls. In large installations, with many poles, this can become an especially significant problem.

Floor receptacles are available in two types; so called "tombstones" which consist of a small electrical box which rises up from the floor about 6" to 8" and the recessed type which, when closed, are flush with the floor. With both types, cords are subject to being kicked loose or broken inadvertently due to their usual placement under furniture. The "tombstone" type also severely limits furniture arrangement because it is a severe tripping hazard unless it is located under or immediately adjacent to furniture. The recessed type is more flexible because it can occur in circulation areas (when not in use) without hazard, however, it is even more susceptible to inadvertent dislodging or breakage of power cords. Some types of recessed boxes also include a cord locking mechanism which improves the installation by reducing the danger of dislodging.

Raceway installed under tables connected to flush floor outlets (easily dislodged)

Often only limited numbers of computers per classroom are initially wired and installed with plans to add several more per room in the future. In order to reduce the cost of future installation, limit the amount of exposed future wiring, and reduce the time needed to install future workstations yet retain low initial costs for wiring and cabling, a prudent school system will install empty power and network boxes with conduit during the initial installation. These empty boxes can be wired when needed without breaking into walls, other destruction or unsightly exposed raceway or wires. Empty conduits (with a pull cord) should be stubbed above the ceiling for future access, or, for slightly additional cost, stubbed and capped at the entrance to the main cable trays running down the corridors.

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Computer and Keyboarding Labs

Computer Lab-PC's not visible from normal teaching station

Computer Lab-PC's visible from normal teaching station

Computer and keyboard labs have similar requirements (on a per computer basis) as those in a regular classroom. Substantial additional space must be allowed, however, for circulation between banks of workstations, teaching area with marker and bulletin boards, fileserver and incidental areas. A self-contained computer lab should generally be about 1,000–1,200 square feet (about 40 square feet per workstation); similar to the size of a traditional business or typing lab. Considerations for circulation of teachers among student workstations, student view of markerboards, overhead screens and teacher view of student workstations must be well thought out. With large numbers of computers, it is difficult to manage glare from sunlight unless the room is located with north facing windows. Additionally, consideration should be given to the use of indirect or parabolic reflector lighting fixtures to control glare on screens. Printers should be located to provide easy access for all users and should be plentiful enough so that all students can print out that day's work in a short period of time at the end of a class period. To be flexible, a variety of software and hardware should be installed so that specialized projects can be worked on after school hours and work can be brought from home in differing disk formats.

Additional information on planning computer labs can be found in *Learning Connections: Guidelines for Media and Technology Programs*, Appendix E, Revised July 1991.

Media Centers

Media Centers are often the central core for technology in schools. Such functions as central head-end rooms for computer networks, central fileservers, automated catalogs, CD-ROM stations, modem connections to outside sources, audio/visual interfaces, computer classrooms and regular workstations are often located within the Media Center and its support spaces. A media specialist is frequently the most highly trained in the setup, operation and maintenance of these systems and thus is often assigned responsibility for them. In a large school or high school it may become necessary to assign a full time staff member whose primary responsibility would be the operation and administration of these systems. If a separate staff member is assigned this function, only the media center related aspects of technology need be located within the media center; main network equipment may be located elsewhere.

Within the Media Center Main Room, the following types of computers are currently being installed:

- Automated (on-line) catalog stations scattered around the entire room as well as one or more units at the circulation desk for check-in/check-out purposes. The scattered stations should be located in the reference, non-fiction and fiction areas and should be configured to allow printing to conveniently located printers. These units can either be dedicated stations for automated catalog or combined with CD-ROM readers for on-line reference material and/or general purpose workstations.
- CD-ROM workstations: These units are currently used predominately for reference material supplied in CD-ROM format as well as back issues of periodicals. CD-ROM is frequently replacing traditional printed (book) reference materials. Because they are often used for basic reference research, it is important that several workstations be located in the reference area. They should be networked to the other units for flexibility. CD-ROM towers which can access multiple discs simultaneously can be located in the main head-end or file server room
- General purpose workstations: These units should be equipped with word processing, math and other software and networked to allow access to the automated (on-line) catalog and CD-ROM units. Several stations should be provided (depending upon the age and number of total students) for typing of reports, term papers, research notes, etc. The units should be supervisable by media center staff and could be located away from the main RLV in an alcove or other area.

Media Center file server and CD-ROM tower

An excellent source of information on planning Media Centers can be found in *Learning Connections: Guidelines for Media and Technology* produced by the Division of Media and Technology, NC Department of Public Instruction, January 1992.

Media Center workstations with separate keyboard trays

Head–End and File Server Rooms

This is the space or room where major components of the technology and network systems interconnect to each other and to other systems external to the school. Media Center functions may include an automated catalog file server, CD–ROM units, integrated communications central equipment, MATV equipment, VCRs and other specialized equipment. Schoolwide network equipment, file servers, modems, patch panels, interactive TV controllers may also be located here. Size of the space, extent of electrical and HVAC is entirely dependant upon the extent of planned equipment. It must be air conditioned year round. A small school with limited technology may adapt a small portion of the media center workroom for this use. A larger or technologically advanced school may require a separate room of 450 to 800 square feet or more to house all of its equipment. The room should be very secure, with high quality door and window locks and controlled access limited only to those maintaining the system.

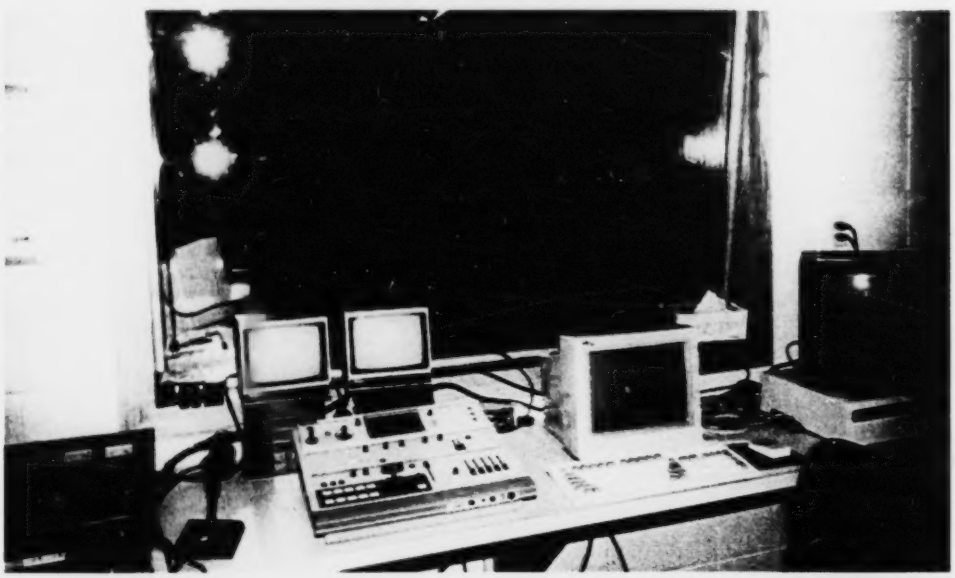
Typical file server for classroom wing

If the school is large enough to require a network administrator, the administrator's office space should be combined with or be adjacent to the head–end and main file server area for maintenance purposes.

Media center head-end rack

Special Use, CADD, Graphics and Vocational Labs

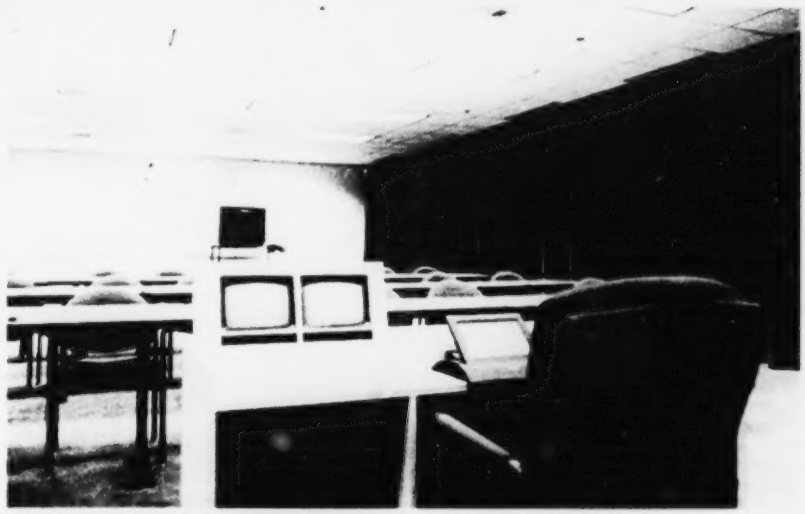
These spaces are specialized and have individualized computer hardware and software. Equipment is often much more expensive and elaborate than average. They include "State of the Art" processors, oversized monitors, large hard drives, extensive memory, specialized printers and plotters, robotics, computer aided machining equipment and specialized software. Because of their high cost and the sensitive nature of this equipment, it is more prone to damage and theft. For this reason, these spaces often need to be tightly controlled by the instructor and equipped with high quality locks. Sizing, layout and physical amenities of the spaces should be modeled after similar uses in private industry or as developed by the educational program for the specific course of study. In vocational and arts areas, these workstations should be located away from dirty or dusty areas, often in another separate space separated by glass walls or windows for visual control.



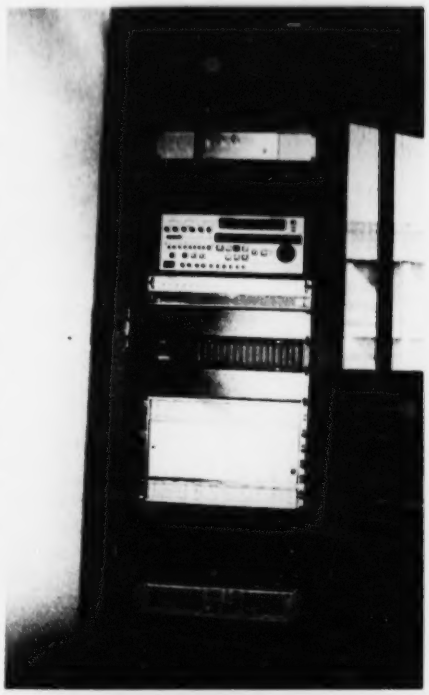
Video production studio control equipment

Distance Learning and Information Highway Labs

These spaces are designed to provide a classroom setting in which the instructor may be present or be remotely located and interacting with the students via high speed two way video, audio (and possibly data) signals. A simple lab could consist of a normal classroom sized space. A teacher station at the front would include a table with a ceiling mounted camera aimed down to a flat work surface and another camera pointed toward the student area. Several monitors will need to be built-in to the teacher station so that the teacher can see and monitor students at remote locations. A third camera would be aimed toward the teacher. Audio signal would be provided by a microphone for the teacher plus one microphone (table mounted) for each pair of students. A sound/speaker system allows voice audio signals from these microphones or from those at a remote learning lab to be heard. Very large wall or ceiling mounted TV monitors are needed for students to see the instructors and students at remote sites. A separate control booth of 60–150 square feet is preferred. This space can contain the necessary control and monitoring equipment mounted in a rack or other method. If a separate control space cannot be provided, similar square footage for this purpose can be allocated within the lab itself. Normal classroom lighting levels are probably adequate; however, ability to control lighting levels with multiple level switching or dimming is desirable.



Information highway/Teleconferencing lab teacher station with monitors for viewing remote lab sites



Typical equipment rack located in control room

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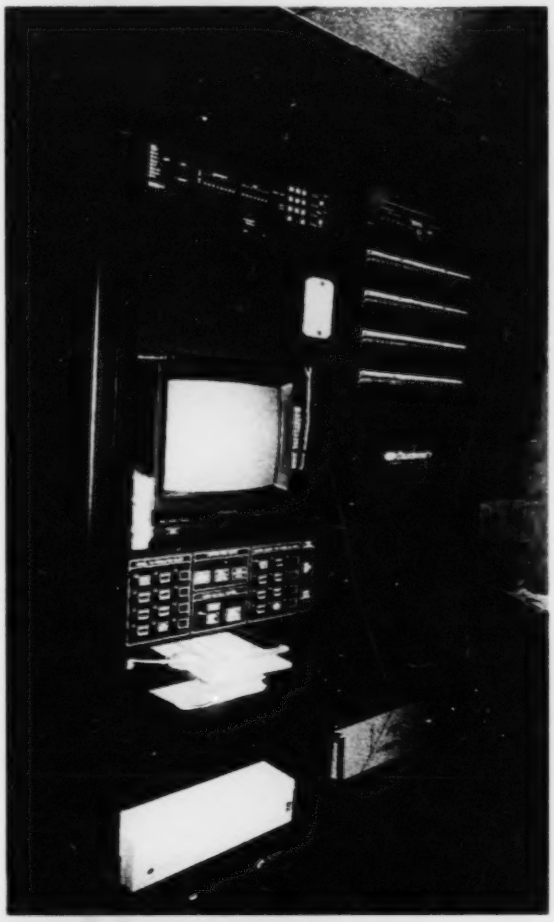
More elaborate labs can also be constructed in which flexible space for special productions is provided. Moveable cameras, custom props and specialized sound systems can be installed similar to commercial broadcast studios. These are custom labs; consequently, size and amenities are entirely dependant upon anticipated uses.

Information Highway/Teleconferencing lab.
View looking toweard teacher station.
Note monitor for live video of students at remote sites

Administration Areas

The full computerization of administration areas is quickly becoming standard in schools. Student Information Management System (SIMS) has been in place for many years. Secretaries and receptionists use personal computers for correspondence, newsletters, reports and other tasks.

New uses for personal computers in school administration areas are becoming apparent every day. Newer uses include access to student records by guidance staff, principals and assistants, interface with energy control systems, Transportation Information Management (TIMS), connections to the central office through a Wide Area Network (WAN), software for scheduling and bell control, homework assignment hotlines, attendance notification and many more tasks.



Integrated communication rack system in administration

The requirements for personal computers in administration areas are similar to those elsewhere in the school. Plans should be made for all staff members to eventually have a personal computer on their desk which is connected to the school-wide network. Printers may be located at convenient central locations such as workrooms and secretarial areas. Access to the network will enable such features as access to student records and transcripts, shared program materials, accountability analysis and reporting, attendance reporting, electronic mail (Email) within the school, the central office and the Internet, as well as printer sharing for efficiency.

Additional space requirements for personal computers in individual staff offices are minimal. The monitor can be placed on the desktop with the CPU either under the monitor or on the floor adjacent to the desk. Slight additional air conditioning load will be incurred per office, but if installed throughout an administrative suite, additional air conditioning tonnage will be necessary based upon the number of units.

Other Uses of Technology in Schools

The use of technology in schools is not limited to education. Many systems have been developed to improve facility management, building maintenance, food service management, inventory/ordering of expendable supplies and other areas.

Energy management and HVAC equipment control technology systems have been extensively developed. Temperature and humidity can be monitored and controlled automatically from a computerized system in the school system central offices. This system can monitor thermostats and control equipment so that large motors or air conditioners do not come on simultaneously, thus "beating the peak" and reducing high electrical demand charges without significantly effecting comfort. Additionally, this technology can monitor the operating efficiency of the equipment itself, alerting the maintenance department when repair or tune-up is required.

Food service systems are available which perform sales (cash registers) accounting, inventory control and even ordering of supplies. These systems can improve accounting, reduce errors and allow much more effective management.

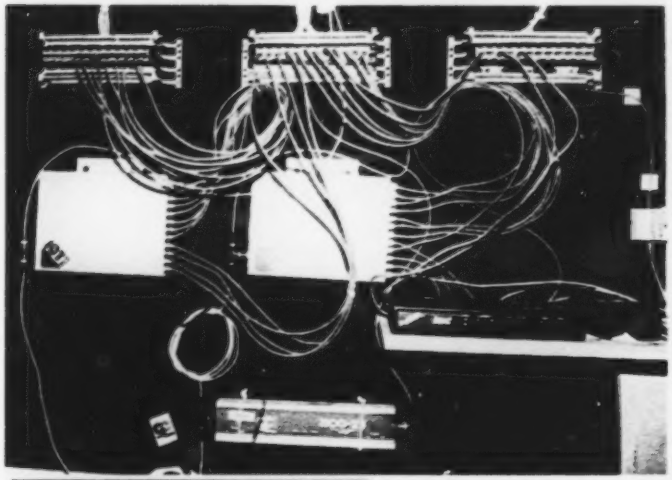
Network systems connected to the school system maintenance department allow work orders to be issued from the school principal, vastly improving response time and allowing effective record keeping of problems and repairs. Custodial supplies and inventory can be included, ensuring that supplies are available when needed. Teacher and office supplies can be ordered and inventoried at each school, linked to the central office by Wide Area Networks (WAN) to take advantage of larger purchase orders and effective distribution of appropriate materials to each school.

Facility Management systems allow tracking of major building maintenance and improvement projects. Major deferred maintenance items such as reroofing, electrical and HVAC system upgrades, painting, etc. can be scheduled and budgeted years in advance. If the timetable of these predictable maintenance items is known and planned for, funds can be allocated in upcoming budgets without having to contend with "emergency repairs" when boilers age out or roofing becomes "unrepairable."

"Property Accounting" drawings and databases of the entire school system can be easily maintained and updated. This information can be invaluable for many departments within the school system. Maintenance departments use plans and databases to perform repairs in specific locations, develop painting schedules, locate underground utilities, schedule deferred maintenance and many other functions. Central offices can use the information to maintain student capacity information and develop long-range plans to accommodate growth in student population and replace ageing facilities. Schools can use their own plans to develop evacuation plans, teacher assignments as well as maps for new students and visitors.

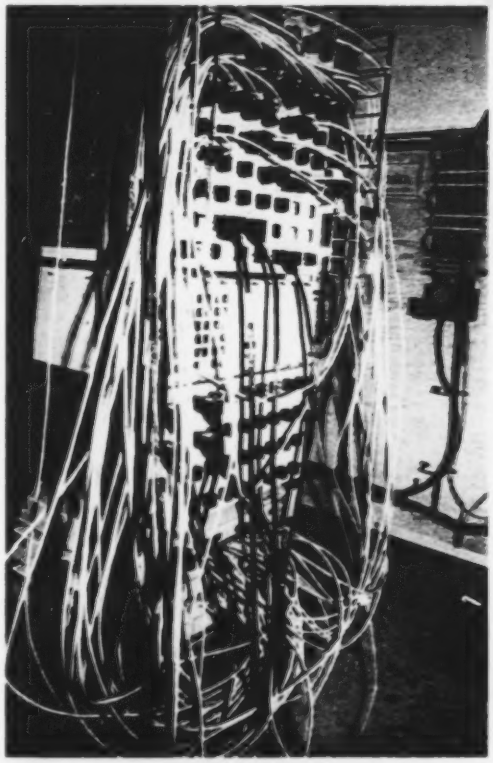
Network Wiring and File Server Closets

These areas are similar to head-end rooms but on a much smaller scale. Small rooms dedicated for network wiring connections need to be established to serve various areas of the school.

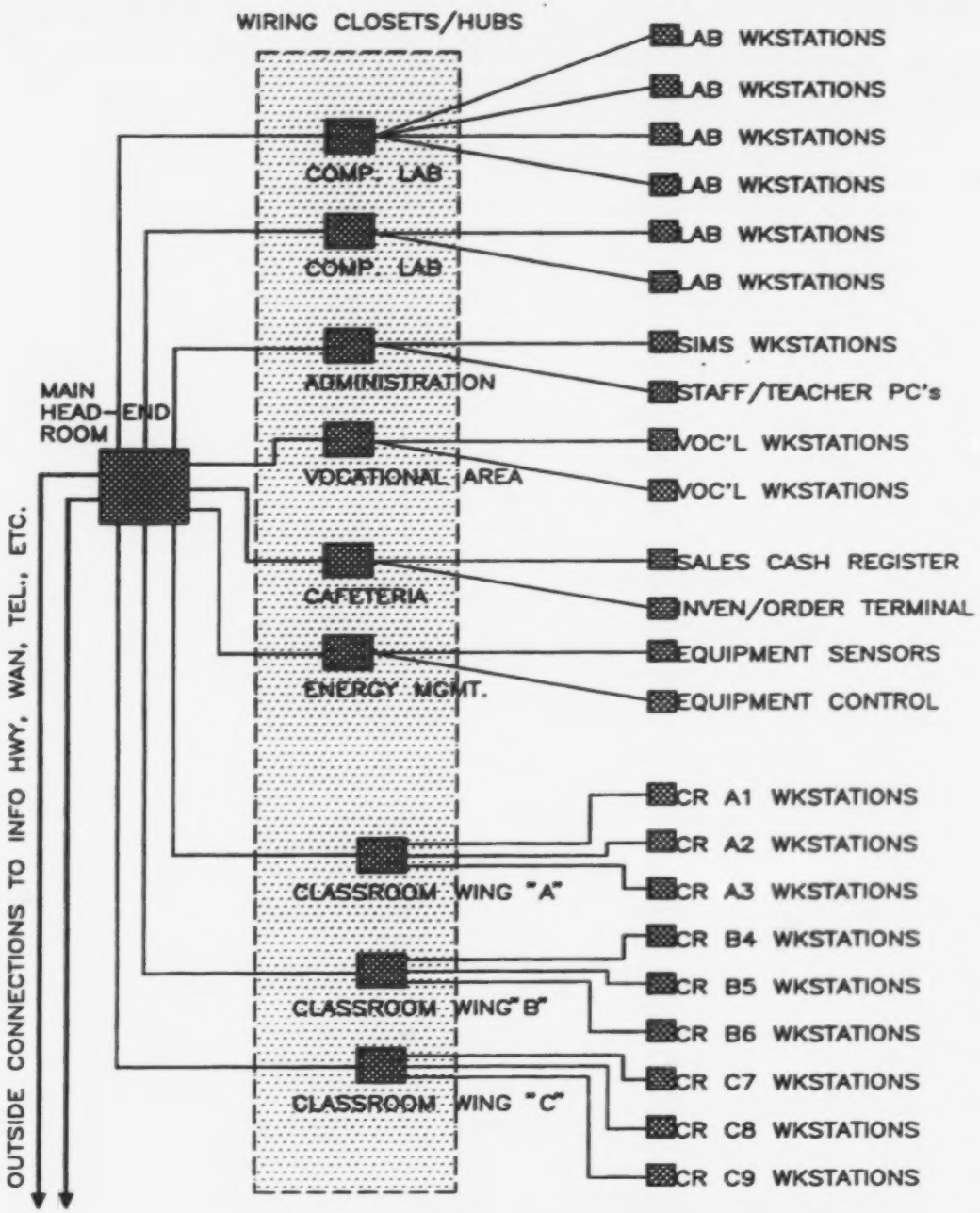


Typical small wiring closet-wall mounted

The space is often a small wiring closet with space on a wall for mounting of connection terminals and hubs. A large piece of fire-retardant treated plywood is usually mounted on the wall for this purpose. More elaborate systems may require free-standing rack systems for mounting of equipment, hubs, transceivers, etc. In a simple, wall mounted system, a 5' wide by 3' deep closet for each building wing may be provided, however, as the network grows, a space of this size may not allow the installation of a future rack system and other equipment. More elaborate/rack systems may require closets of 70 to 110 (or more) square feet. Number and location of closets is set by maximum length of cable runs and logical zoning of the structure. Current types of cable usually require that the closet be no further than 300 feet from the most remote workstation it serves. Some types of equipment placed in these rooms may require that the spaces be heated and air conditioned within narrow limits but they should be ventilated regardless. Two to six (and maybe more) electric duplex outlets on at least two circuits will be required for equipment. These circuits should be isolated, dedicated for network use and should be connected to an uninterruptible power supply (UPS) in the event of power failure. *STS-1000 Telecommunications Wiring Guidelines* is an excellent source of information for wiring, conduit, cabletrays and wiring closets.



Typical large wiring closet-rack mounts



Typical school network schematic layout

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A Final Word

Because technology is constantly advancing, a publication of this sort cannot remain current. As new equipment is introduced, its physical and environmental needs and impacts are certain to change from that of the previous generation. New technology can be expected to impact buildings in new ways. Laptop computers may negate the need for additional electrical and air conditioning capacity. "Wireless" networks may significantly reduce or eliminate the need for cabletrays and conduit within a building or classroom. Integrated voice, data, and video within a single unit may combine the current telephone, TV monitor and personal computer into a single, portable unit. Many of these concepts are yet to be fully developed and may, or may not, become economically viable in a school environment. In order to accommodate these certain changes in needs in the coming years, we must design our facilities to be flexible, with sufficient space and infrastructure capacity to meet the changes in technology that will be upon us. Rather than attempt to design our schools for the "ultimate technology," we need to design for flexible spaces and systems to accommodate the inevitable evolution of technology.

References and Additional Resources

Note: The documents listed below have been developed and/or distributed to the schools in North Carolina by the Media and Technology services of the Department of Public Instruction

North Carolina Instructional Technology Plan. North Carolina School Technology Commission, Raleigh, NC, December, 1994. Recommendations for the implementation and use of technology in North Carolina Schools.

North Carolina Instructional Technology Plan Guide: Technological Recommendations and Standards. (Draft). Center for Educational Leadership and Technology, Raleigh, NC August, 1994. Recommendations for equipment configurations.

Learning Connections Guidelines for Media and Technology Programs. Division of Media and Technology Services, NCDPI Raleigh, NC, January 1992 . A comprehensive planning guide for school media centers and their associated spaces.

STS-1000 Telecommunications Wiring Guidelines. State Telecommunications Services, Raleigh, NC Revised March 12, 1993 (STS-2000 is expected to be released shortly). Voice and data wiring and cabling standards for State-owned buildings (primarily government offices and university).

Requirements and Procedures for Installing Local Area Networks. State Information Processing Services (SIPS) Raleigh, NC Revised March 21, 1994. Responsibilities and requirements for the installation, operation and management of LANs supported by SIPS and the IRMC that are connected to the North Carolina Wide Area Network (WAN).

Technology Standards and Supporting Products for Local Area Networks. State Information Processing Services (SIPS) Raleigh, NC Revised July 14, 1994. Statewide standards and naming conventions for networks.

Guidelines to Provide Uniform Wiring Service For Telecommunications in North Carolina Public Schools. Department of Public Instruction July 2, 1991. Describes recommended types of cables, conduit, wiring boxes and network closets.

A Primer on Cabling Design and Implementation: Considerations for Decision Makers. North Carolina Department of Public Instruction, May 1992. Descriptions of different types of cabling systems, LANs, WANs and current uses of technology in the schools.

Photographic Credits

Many thanks to North Carolina school systems listed below for their invaluable assistance with this publication. Their technology staff proved very helpful with advice and hints about particular aspects of systems which work efficiently as well as those which tend to cause problems.

Page 13: Leesville Middle School, Wake County Public Schools

Page 14 Left: Jordan High School, Durham County Public Schools

Page 14, Right: Leesville High School, Wake County Public Schools

Page 16, Top: Jordan High School, Durham County Public Schools

Page 16, Bottom: Jordan High School, Durham County Public Schools

Page 17, Top: Clayton Middle School, Johnston County Public Schools

Page 17, Bottom: Clayton Middle School, Johnston County Public Schools

Page 18: Asheville High School, Asheville City Public Schools

Page 19, Top: Teleconferencing Lab, NC Education Building, Raleigh

Page 19, Bottom: Teleconferencing Lab, NC Education Building, Raleigh

Page 20: Teleconferencing Lab, NC Education Building, Raleigh

Page 21: Clayton Middle School, Johnston County Public Schools

Page 23, Left: Jordan High School, Durham County Public Schools

Page 23, Right: Wiring Closet, NC Education Building, Raleigh

Notes